



Identification and Analysis of Innovation Value Stages in Research Fronts and follow-up studies

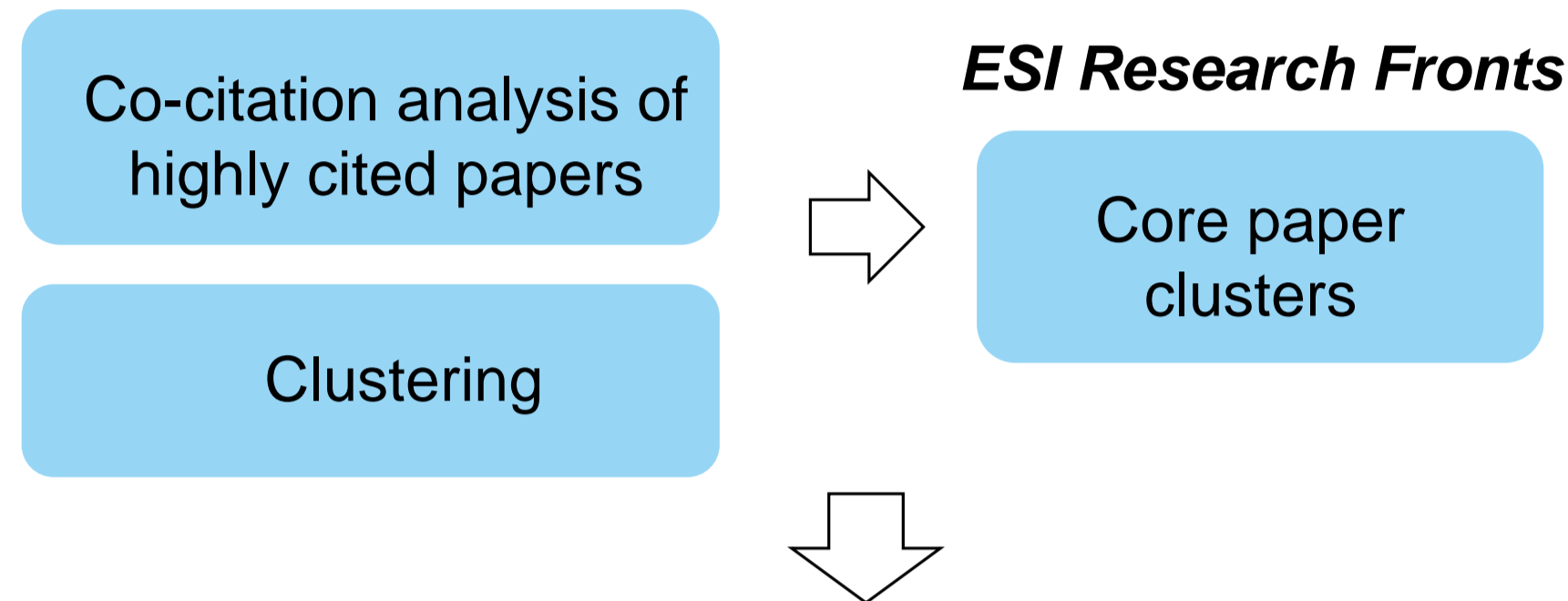
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Problem

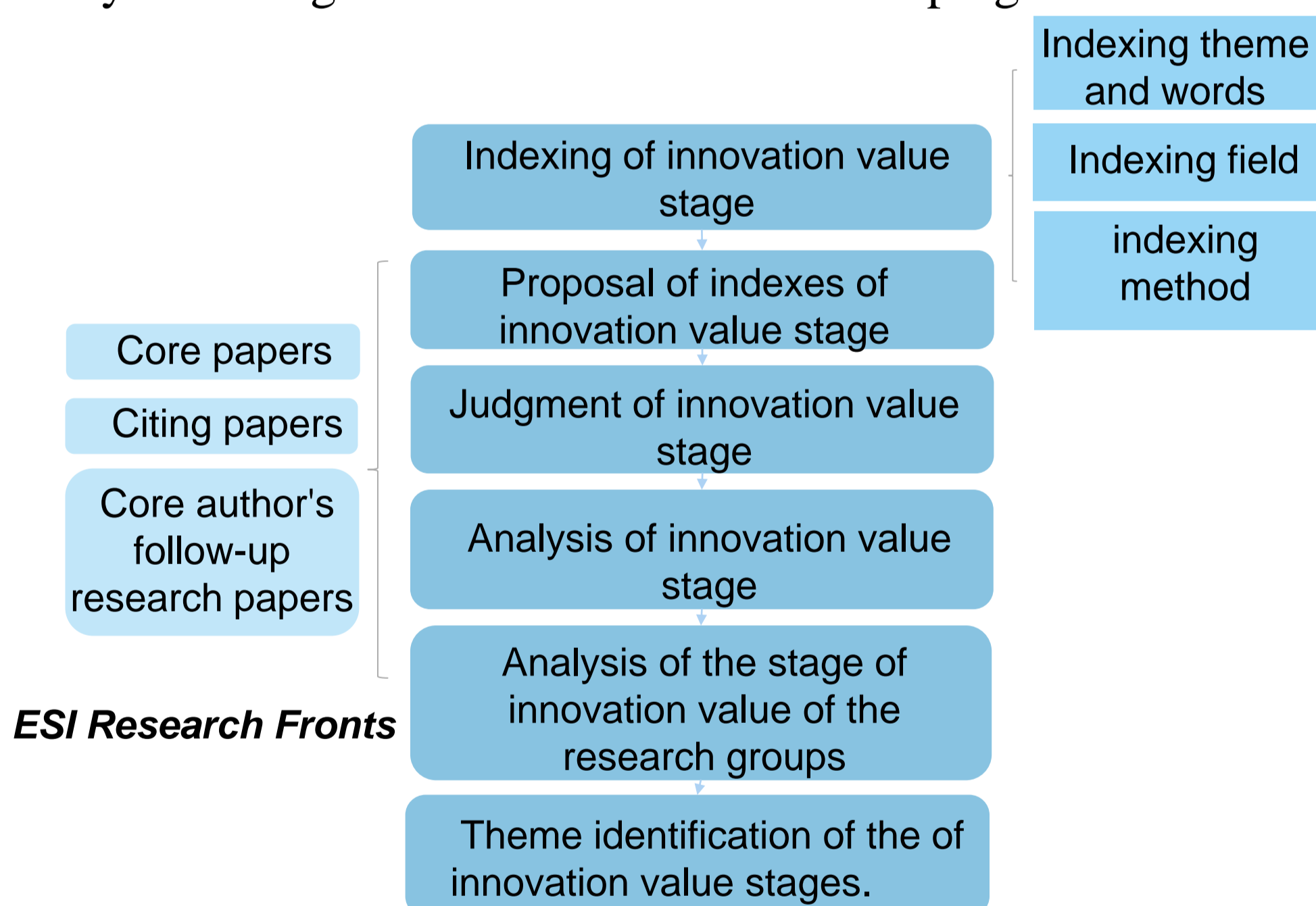
Research Fronts are often recognized as the most promising emerging research areas or research topics in a period, which have been paid much attention by research funding departments, research managers and researchers.



The question **"What innovations are being addressed in research fronts and follow-up studies?"** is one of the concerns of research fronts users.

Method

The expression of **"innovation value stage"** is considered as a staged division and classification of the value and function of basic scientific research in the process of knowledge innovation. It can further expand the bibliometric analysis from grammatical and semantic to pragmatic.



Research front tracking methodology system based on innovation value stage

Indexing of innovation value stage

- indexing themes are determined by literature research and expert consultation.
- indexed from the three structural fields of title, abstract and keyword.
- indexing method adopts automatic word-indexing.

Innovation value stage indexes

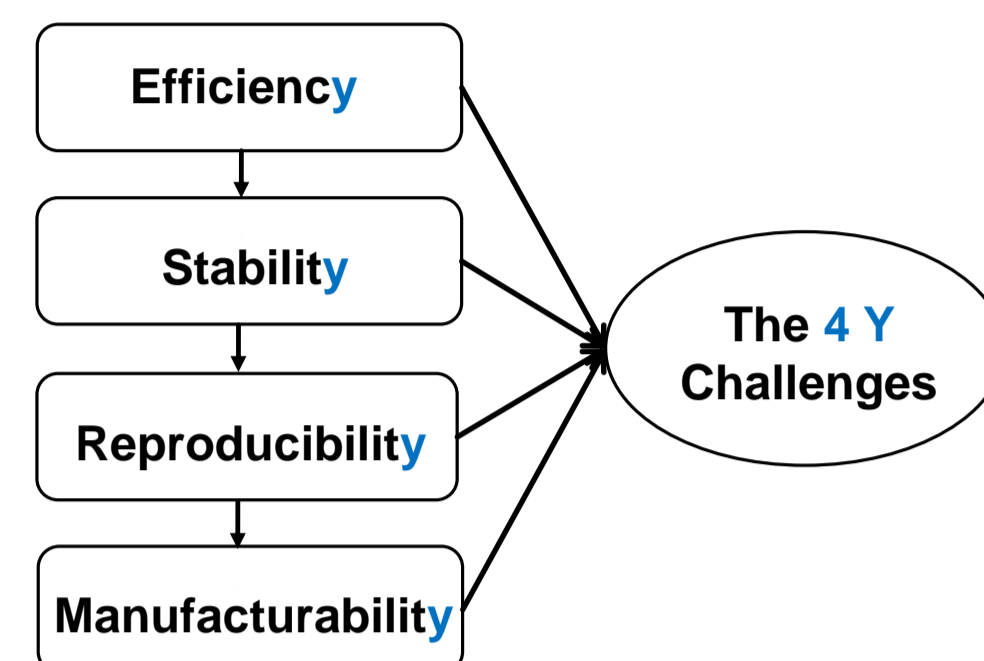
- the scores are scored according to the position of the indexing words (keyword 4 points, title 2 points, summary 1 point), and the scores of each value stage of each paper are calculated separately, finally, the value stage which has the maximum value is taken as the value stage of the paper.

Theme identification of the of innovation value stages

- extracting sentences where the indexed words are located in the abstract, natural language processing, phrase cleaning, expert interpretation.

Empirical research

The corresponding empirical research is carried out with the research front of **"CH₃NH₃PbI₃ perovskite solar cells and inorganic hole transport materials"**



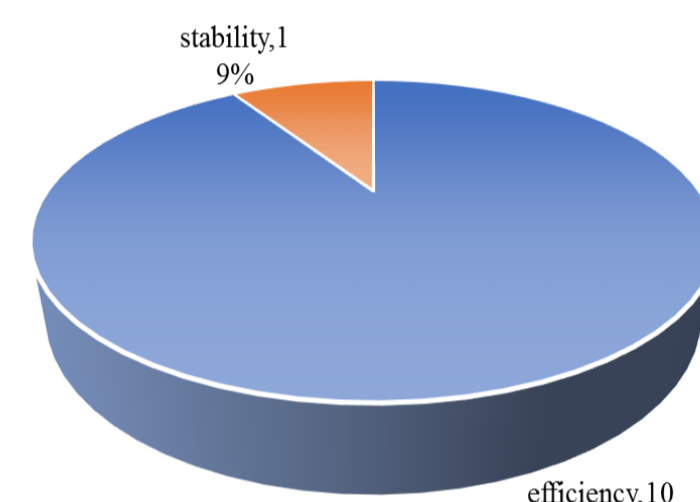
Major innovative value stages in solar cell field

Specific indexing scheme for innovative value stage

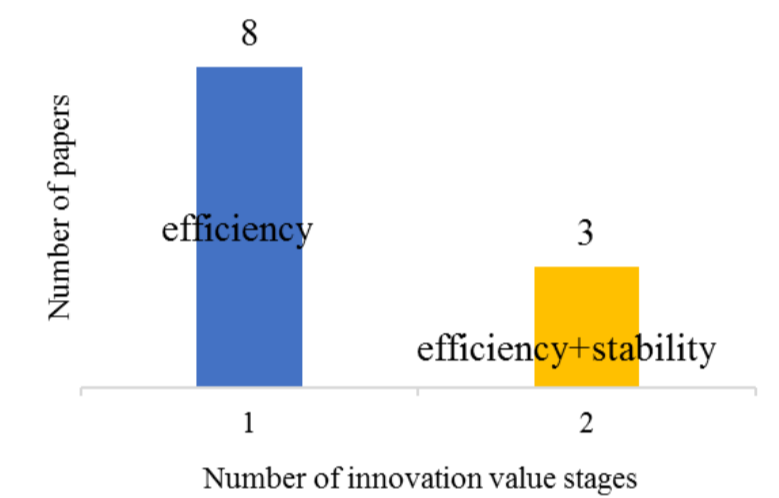
Theme	Indexing scheme
Efficiency	efficiency OR efficient OR effective OR effectiveness OR efficiently OR inefficient OR PCE
Stability	stability OR thermalstability OR photostability OR stable OR multistable OR phasestable OR photostable OR stabilised OR stabilities OR stability OR stabilization OR stabilize OR stabilized OR stabilizer OR stabilizes OR stabilizing OR airstable OR stability OR airstability OR environmentalstable OR reproducible
Reproducibility	reproduce OR reproduced OR reproducibility OR reproducible
Manufacturability	manufactory OR manufacture OR manufactured OR manufacturing OR costeffective OR costefficient OR Large-area OR Low-cost OR fabricate OR fabricated OR fabrication

Core papers

- the main value stage of the core paper is efficiency.



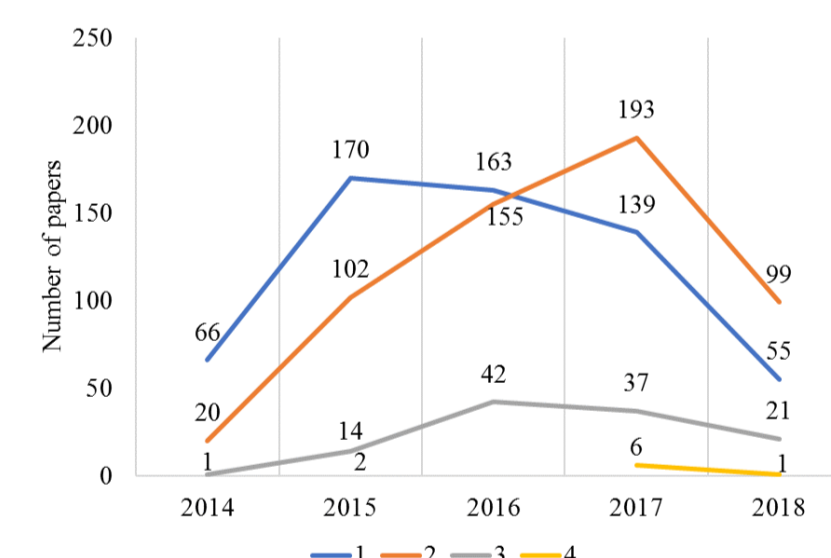
Distribution of value stages of core papers



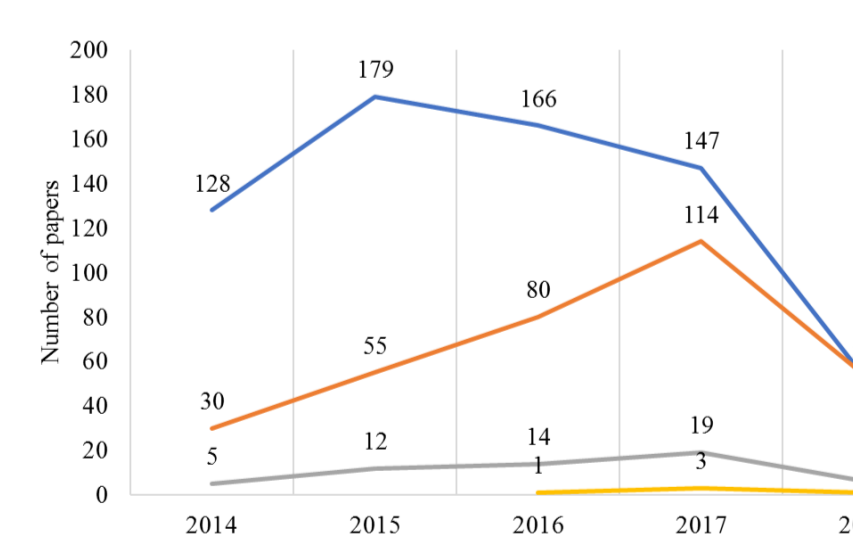
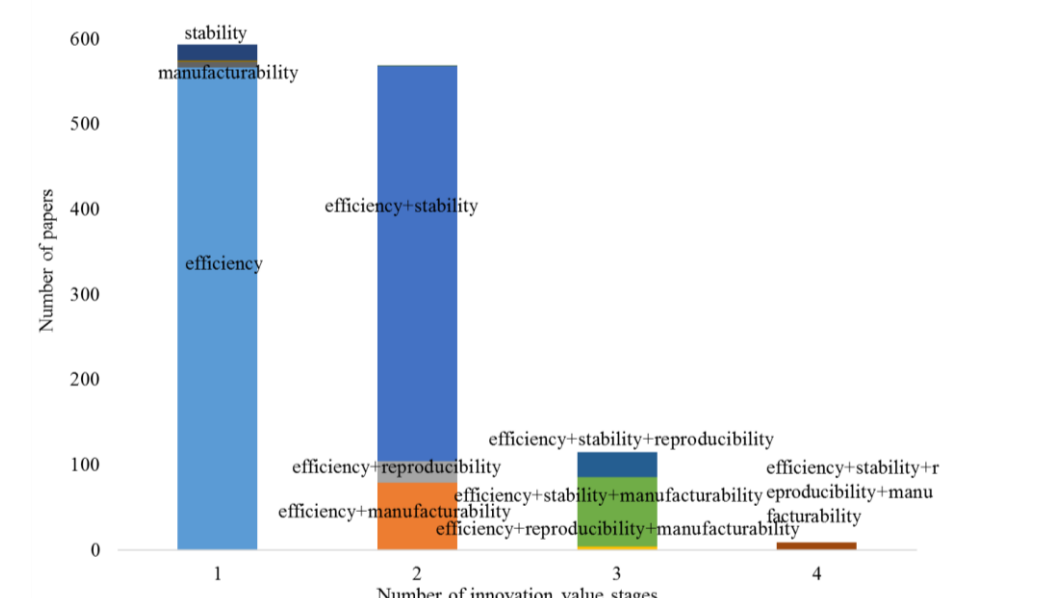
The distribution of the number of innovation value stages of core papers

Citing papers and the authors' follow-up research papers

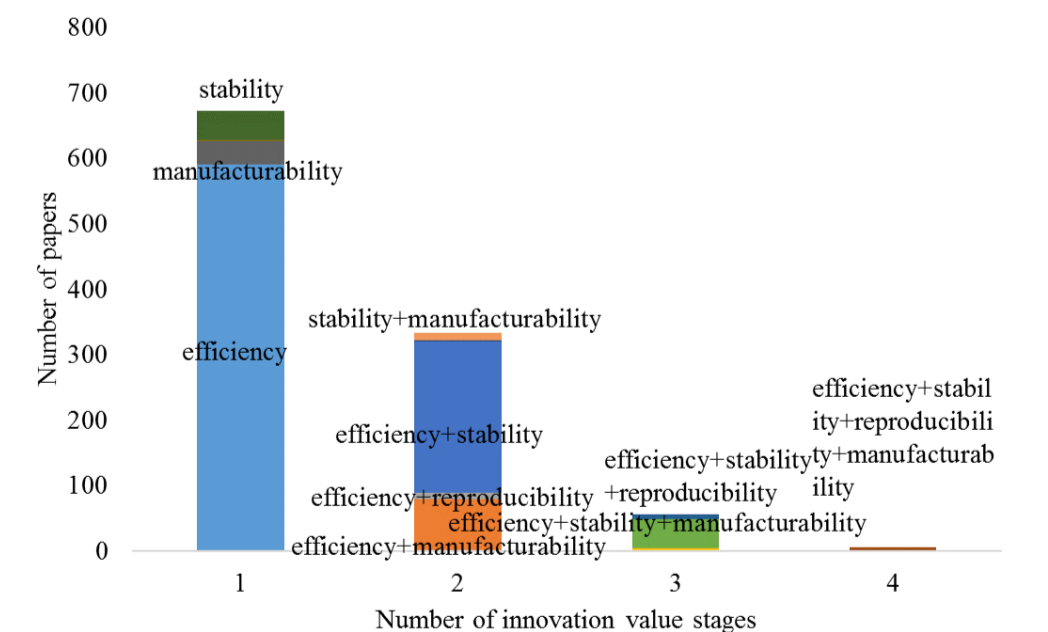
- still focusing on efficiency, but the research value dimension is expanding, whether it is the overall perspective or the research dimension of a single paper, the research is oriented towards the comprehensive application of stability, reproducibility and manufacturability.



The number distribution and annual change trend of the innovation value stage of citing papers

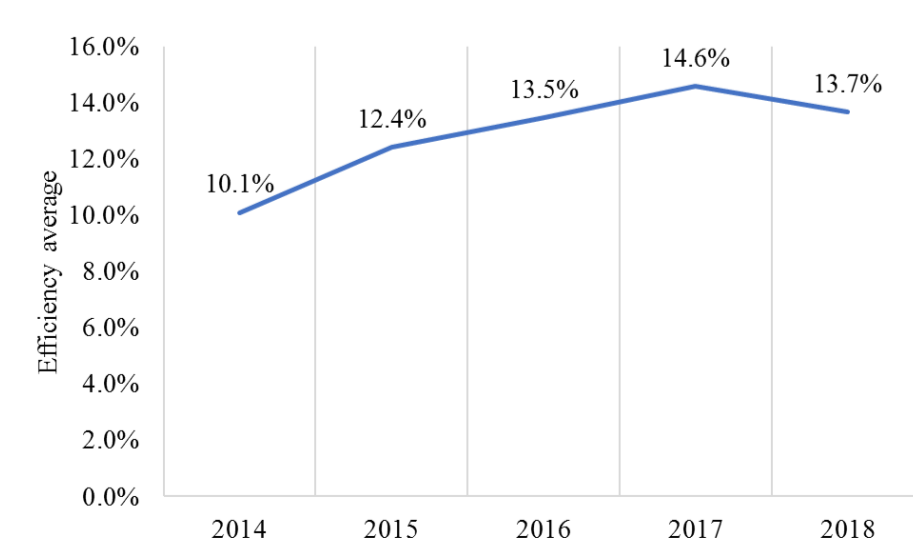


The number distribution and annual change trend of the innovation value stage of author's follow-up research papers



Theme identification of the "efficiency" value stage

- the efficiency value of the efficiency value stage was extracted, and the research on efficiency was found to increase year by year.



Annual trend of averaging efficiency of citing papers

Main related topics of the efficiency value stage of citing papers				
2014	2015	2016	2017	2018
spiro-OMeTAD	hole transport material	hole transport material	hole transport material	hole transport material
CH ₃ NH ₃ PbI ₃ film	open-circuit voltage	open-circuit voltage	open-circuit voltage	open-circuit voltage
CuI	spiro-OMeTAD	current density	spiro-OMeTAD	hysteresis
fill factor (FF)	PEDOT	fill factor	PEDOT	spiro-OMeTAD
copper(I) thiocyanate (CuSCN)	CH ₃ NH ₃ PbI ₃ film	spiro-OMeTAD	CH ₃ NH ₃ PbI ₃ film	Ag
high open-circuit voltage	fill factor	CH ₃ NH ₃ PbI ₃ film	fill factor	enhanced performance
hole conductor	J(sc)	copper(I) thiocyanate (CuSCN)	hysteresis	fill factor
photocurrent	morphology	hysteresis	interface	interface
TiO ₂	perovskite film	PEDOT	current density	J(sc)
alloy NPs-based OSCs	photocurrent	interface	ZnO	NiO _x -based device